Pprime Institute, (CNRS linked with the University of Poitiers and ISAE-ENSMA) located in Poitiers, France is a research laboratory specialized in the fields of Physics and Engineering Sciences. Its research activities cover a large range of topics from physics of materials,mechanics of materials to mechanical engineering and fluid mechanics and energetics. It is about using this set of competences, recognized at both national and international levels, to favor collaborations and synergies between different disciplines/subjects, and to respond appropriately the needs of the socioeconomic sector. The privileged areas of application are the transportations and the energy, with a careful consideration given to environmental aspects.

The *Laboratoire d'Étude des Microstructures et de Mécanique des Matériaux*, (LEM3, Université de Lorraine, CNRS, Arts et Métiers) located in Metz (France) is a center for transdisciplinary experimental and theoretical research combining mechanics of solids and metallurgy, materials science, chemistry, and physics. By maintaining the balance between basic and applied approaches, it ensures a strong visibility of its cutting-edge research and an effective knowledge transfer to industrial partners. The worldwide scientific excellence of the LEM3-Université de Lorraine was recognized in 2020 by the Shanghai Ranking: 43rd in "Metallurgical Engineering".

To support our collaborative research through our respective LABoratories of EXcellence (LabEx DAMAS and LabEx INTERACTIFS), we are looking for a

Doctoral Researcher

Surface hardening and fatigue behaviour of titanium alloys induced by multi-interstitial followed by mechanical surface treatments: effect of property gradient *(description next page)*

Start date: **October 1st 2021**

Your tasks

- You will perform the surface treatments of the samples and detailed analyses of their microstructures.
- You will perform cutting-edge techniques for characterizing microstructures, especially by electron microscopy.
- Your results will be discussed in the framework of materials physics.
- You will interact with researchers from several countries.
- You will publish your work in international scientific journals.
- You will share your time between Metz (France) and Poitiers (France).

Your profile

- You must have a master's degree in materials physics, **passed with high honors**
- You must have good knowledge of materials physics, crystallography, metallurgy.
- You have good written and verbal communication skills, and enjoy working in an international team.
- Good English language skills are required.

We offer:

- Dynamic international environment
- Direct supervision by tenured senior academics
- Enrolment in graduate school program
- Cutting-edge experimental facilities
- 3 years fixed term contract (monthly gross salary: ~1800 € including healthcare)

Further information and application

For further information and application – **resume including addresses of referees and your exam scores (bachelor and master)** – please contact:

Prof. Luc PICHON, luc.pichon@univ-poitiers.fr Dr. Antoine GUITTON, antoine.guitton@univ-lorraine.fr

Application without enclosures mentioned will not be accepted.

Application: https://www.antoine-guitton.fr/?page_id=356

Scope of the project:

Our objective in this collaborative project between LEM3/LabEx DAMAS and Pprime Institute/LabEx INTERACTIFS in connection with the Danish Technical University (DTU) is to open new routes for surface hardening and wear resistance in titanium alloys. Indeed, most of existing treatments produce generally a surface layer composed of very hard compounds leading to “eggshell effect” under wear solicitations. Therefore, deep gradient with improved mechanical resistance is here targeted. Based on our mutual expertise both in thermochemical (multi-interstitial) and mechanical surface modifications (Surface Mechanical Attrition: SMAT), the underlying hypothesis of our research is to determine the synergy of simultaneous or sequential diffusion of interstitial elements, and its improvement thank to following SMAT treatments. Moreover, modifications of the bulk material due to the thermal treatments has to be avoided to minimize the weakening of the macroscopic mechanical resistance.

The use of multiple interstitial elements, for example nitrogen, carbon and oxygen together, was shown to lead to the enhancement of both the surface hardness and of the gradient depth, as compared to any binary combination. The present project will study complementary aspects, exploring the additional effect of SMAT, in combination with the most promising thermochemical treatments, and investigating the induced mechanical properties under tensile and fatigue solicitations.

A few pertinent combinations of treatments will be determined to provide the best targeted functional properties, that is the appropriate surface hardness and elasto-plastic properties leading to a better wear resistance. These treatments will be applied to dedicated samples of specific titanium alloys, such as metastable β alloys widely used in biomedical applications, presenting well characterized tensile and fatigue behaviors.

During the project, the doctoral researcher will have to conduct both surface treatments (also in combination), physical and chemical surface characterization (including the determination of potential stress/strain induced phase transformation and the effect of the local chemistry on the kink band formation nucleated during SMAT) as well as mechanical tests (including some with in-situ observation under SEM) such as of indentation and fatigue testing.

- Surface treatments will consist in thermochemical plasma assisted (nitriding, carbo-oxidizing or carbo-nitro-oxidizing) followed by mechanical (SMAT) processing. Some specific treatments available at DTU may also be considered. The doctoral researcher will be in charge of conducting these treatments both on the plasma reactor available at Pprime and SMAT available at LEM3. He/she will then characterize the composition and microstructure of the treated layers and the possible modifications of the bulk material resulting from the treatments will be investigated too: various technics are available in LEM3 or Pprime as X-Ray Diffraction, Optical Microscopy (OM), Scanning Electron Microscopy (SEM), Energy or Wavelength Dispersive Spectrometry (EDS-WDS), Glow Discharge Optical Emission Spectroscopy (GDOES), Transmission Kikuchi Diffraction (TKD), Electron Channelling Contrast Imaging (ECCI), Electron BackScattered Diffraction (EBSD), Transmission Electron Microscopy (TEM)…
- Micro hardness and nanoindentation measurements on cross sections will provide hardness gradient and some mechanical characteristics of interest concerning the targeted wear resistance. This part will be operated in the SIMAC team of Pprime and IMPACT department of LEM3.
- After chemical and microstructural characterizations of the samples, tensile and fatigue tests will determine the modifications of the damaging mechanism induced by the surface treatments. In a first step, in-situ tensile tests will be operated in SEM on micro samples and studied by EBSD and ECCI. This first approach, much faster than fatigue testing, will allow a first discrimination of the treatment sequences and will allow the study of the modifications of the damaging mechanism due to the treatments. Low cycle fatigue tests will then be applied to the most promising treatments. This part will be operated in the ENDO team of Pprime Institute.